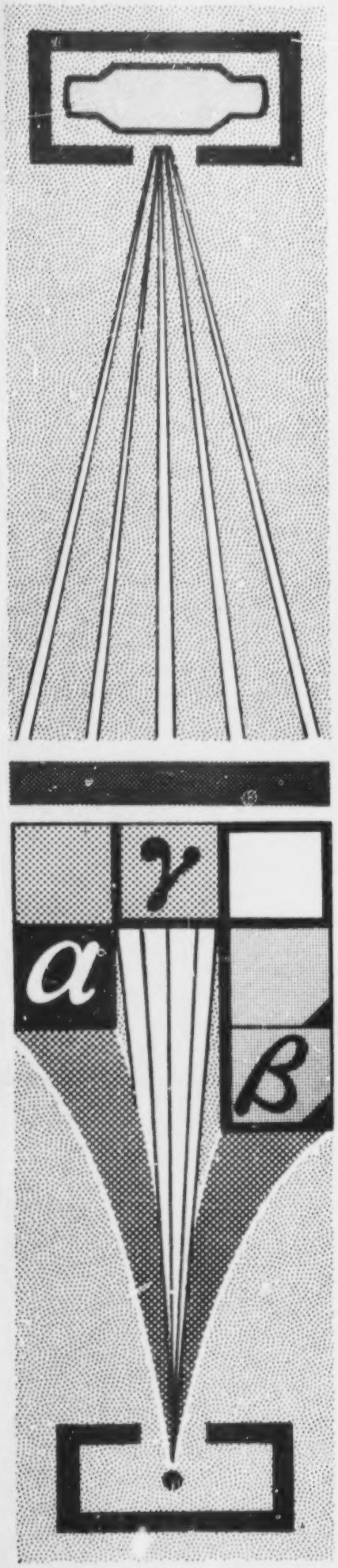


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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

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MORP 67-3

# RADIUM SOURCE INTEGRITY TESTING PROGRESS REPORT

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FEBRUARY 1967

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service
Bureau of Disease Prevention and Environmental Control
National Center for Radiological Health
Rockville, Maryland 20852

# RADIUM SOURCE INTEGRITY TESTING PROGRESS REPORT

An initial contract with General Electric Company's Vallecitos Nuclear Center for testing of sealed radium sources has recently been concluded. The purpose of this contract was to conduct limited integrity tests on unwanted medical radium sources which had been collected for disposal. It was also planned that this initial contract would give guidance for defining areas of further investigation.

The scope of tne contract was limited to:

(1) visual inspection and leak testing of all sources.

(2) evaluating the effectiveness of three reagents for removing surface contamination.

(3) destructive bend and compression tests to investigate the effects of physical stress on integrity of sealed sources.

A total of 64 radium sources of various age and design were received by General Electric for testing and disposal. Table 1 shows tne source type and activities of the 39 sources chosen for testing. These sources include those types most frequently used by the medical profession. The remaining twenty-five scurces were not suited for testing for various reasons. The sources had been collected from State health departments tnrough the Radioactive Materials Section's Radium Disposal Project. Many of these unwanted sources (1) had not been used for a number of years, and/or (2) had been identified as leaking or contaminated. Therefore, the test data collected is not necessarily representative of newly encapsulated medical sources that are currently in use. Although it was requested that calibration certificates accompany the sources when possible, only two of the 39 sources tested had such a certificate. Preliminary dose rate measurements of the sources indicated that several had reported activities which did not agree with those measured. This discrepancy might suggest that all facilities using radium should have:

(1) a calibration certificate for each source, and

(2) a positive means of matching the calibration certificate to the source.

This could be of particular importance in facilities without adequate instrumentation as the only readily available method to identify sources.

Table 1 - Summary of Sources Tested

| Type Source | Number of Sources Tested by Activity | | | | | |
|---|---|---|---|---|---|---|
| | 1 mg. | 5 mg. | 10 mg. | 12.5 mg. | 15 mg. | Total |
| Needles | 2 | 6 | 17 | 4 | -- | 29 |
| Tubes | 2 | -- | 1 | -- | 2 | 5 |
| Plaques | -- | 1 | 4 | -- | -- | 5 |

I. Leak Testing

Each source was checked for leakage and contamination before subsequent testing was done.

The leak testing system consisted of a filter for the collection of radon-222 daughter activity emanating from a leaking or contaminated source. The system included a vacuum chamber, an inert gas purge system, a membrane filter apparatus, activated charcoal traps, and a vacuum system (Figure 1).

The procedure followed was to smear the radium source with a cotton swab and measure the initial removable contamination. The source was then placed inside the vacuum chamber and the chamber evacuated to greater than 20 inches Hg. After allowing time for the short lived daughters to reach equilibrium with radon leakage (about 3 hours), the chamber was purged with helium gas. Daughter particulates were trapped on the membrane filter with the radon gas passing through to the activated charcoal traps. Gas purging and sample collection were generally continued for approximately one hour at a flow rate of one cubic foot per hour. The filter was then removed and immediately monitored with a portable survey meter for alpha contamination. If alpha contamination was evident, the filter was saved for subsequent counting to determine if the contamination was long or short lived. The charcoal traps were to be monitored for quantitative radon measurement; however, preliminary testing indicated that the activity found on the charcoal was insignificant. The chamber and system were purged with helium after each source test.

The system was checked using a source of 50 micrograms of radium deposited on a planchet. The short lived daughters were allowed to reach equilibrium with the radon and the above procedure followed. About 2,000 dpm alpha were collected on the filter during a one hour's purge at one cubic foot per hour helium flow and 22 inches hg. vacuum.

Results from the smear and leak tests are shown in Tables 2 and 3. All five plaques tested were highly contaminated and leaking. Nine of the 34 needles and tubes showed leakage. However, it should be noted that three of the leaking sources did not have removable contamination.

Sources showing contamination but no leakage had in general been previously stored with leaking sources suggesting that a smear test may indicate a false positive result if only this method were used to determine leakage. In all but one case, the activity detected on the filter appeared to be from short-lived daughters. However, in this one case radium or long-lived daughter migration was observed. This source was a plaque which had been identified as being approximately 23 years old and in very poor condition. Ten of the 14 leaking sources were identified as being over 20 years old.

Table 2 - Contaminated Sources - Wipe Test

| Type Source | Number of Sources by Type | | | |
|---|---|---|---|---|
| | Bkgd. | 250-1000 dpm | 1000-10,000 dpm | >10,000 dpm |
| Needles | 18 | 4 | 6 | 1 |
| Tubes | 5 | -- | -- | -- |
| Plaques | -- | 2 | 1 | 2 |

Table 3 - Leaking Sources

| Type Source | Number of Sources by Type | | | |
|---|---|---|---|---|
| | Bkgd. | 400-1000 dpm | 1000-10,000 dpm | >10,000 dpm |
| Needles | 21 | 6 | 2 | -- |
| Tubes | 4 | 1 | -- | -- |
| Plaques | -- | -- | 4 | -- |

Although it is not substantiated by the limited data, tubes should be less likely to leak than needles because of their more rugged construction (1 mm wall thickness vs. 0.5 mm) and less severe usage (usually tubes are used in applicators and are thus not handled as severely as needles which are inserted into tissue directly.)

II. Decontamination Tests

Water as a common noncorrosive liquid, ethanol as a common organic solvent, and dilute hydrochloric acid were used as reagents in an attempt to decontaminate the sources with a minimum of handling time.

Each source was smeared with a cotton swab and the degree of dry contamination established using a portable alpha meter. The sources were then placed into a water bath at room temperature and allowed to soak for five minutes. Next, the sources were removed from the water, air dried and resmeared. Where contamination was still present, this procedure was repeated using the ethanol and the dilute acid, in that order.

Results from the decontamination tests are shown in Table 4. Although there appeared to be some value in soaking the source prior to smearing, there is no apparent value in using all three reagents. With the exception of the two sources where a black surface deposit was removed, each reagent seemed to be equally effective in removing or loosening the contamination. Agitation scrubbing or use of ultrasonics during the cleaning step appears to be logical procedures to increase the effectiveness of the decontamination agents.

Table 4 - Decontamination Test

| Source Condition | Preliminary Smear (dpm) | Post-Water Smear (dpm) | Post-Ethanol Smear (dpm) | Post-Acid Smear (dpm) |
|---|---|---|---|---|
| Leaking Sources | 1400 | 800 | 600 | 600 |
| | 2000 | 3600 | 3600 | 9000 |
| | 7000 | 19000 | 12000 | 20000* |
| | 2000 | 2000 | 2000 | 2000 |
| | 3000 | 8000 | 6000 | 8000 |
| Non-Leaking Sources | 400 | <200 | | |
| | 400 | <200 | | |
| | 1400 | 1400 | 18000* | 18000 |
| | 2000 | 3000 | 3000 | 3000 |
| | 9000 | 9000 | 9000 | 9000 |

*black Surface Deposit Removed

III. Mechanical Bend and Compression Tests

As rupture or loss of integrity of sealed sources presents a large potential problem in regard to contamination and exposure, seventeen needles were subjected to bend and compression tests to investigate the effects of physical stress.

For the bend testing, the sources were clamped into a small vise with one end of the source protruding. The exposed end was then clamped in a fixture and the source bent back and forth in 45° bends until fractured. For the compression test, the source was placed lengthwise between the jaws of the vise and squeezed together until fractured.

Results from the bend test are seen in Table 5. The cladding material for the silver cclored needles was not always known; however, it is likely that in most, if not all cases, it was platinum-iridium. The number of bends required to produce source rupture seemed dependent upon:

1) Ductility of the cladding. The gold needles were quite ductile, requiring seven to ten 45° bends to fracture. On the other hand, the more brittle metal needles generally broke with less than six cycles.

2) Encapsulation. The two doubly encapsulated sources necessitated an extra bend to break the inner tube after the outer cladding had failed.

3) Degree of bend. Increasing the angle through which the source is bent leads to a more rapid failure.

Table 5 - Bend Test (45° Bends)

| Source Encapsulation | Number of Bends to Failure | | | | |
|---|---|---|---|---|---|
| | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 |
| Gold Colored Cladding | -- | 1* | -- | 3 | 2 |
| Silver Colored Cladding | 2 | -- | 3** | -- | -- |

* 60° Bend Used

** Two of the sources were doubly encapsulated

Compression results in Table 6 also showed the gold cladding superior. Complete 180° bends showed only a slight crack at the bend. The silver colored sources all broke easily, and in one case, the needle split longitudinally.

Table 6 - Compression Test

| Source Encapsulation | Observations |
|---|---|
| Gold Colored | Compressed and bent a full 180° without a break. |
| Gold Colored | Compressed and bent a full 180° without a break. |
| Gold Colored | Compressed and bent a full 180° with slight crack developing at bend. |
| Silver Colored | Fractured after 120° bend. Initially a leaking source. |
| Silver Colored | Split longitudinally upon compression. |
| Silver Colored | Needle head broke off; cracked in middle. Initially a leaking source. |

IV. Future Testing

The overall objective of further investigation is to subject additional radium sources to various physical tests which would determine source integrity and the ability of sources to maintain integrity during situations which could be encountered during actual field use. This is being accomplished under another contract with General Electric Company's Vallecitos Nuclear Center.

Radium sources will be subjected to the following types of test:

1. Room Temperature Leak Test

Sources will be leak tested at room temperature to determine what percentage of the sources leak, and also to differentiate between those sources which leak and those which have surface radium contaminat on.

2. Leak Test at Elevated Temperature

Initially leak-tight sources will be tested to determine whether they remain leak-tight at elevated temperatures. Sources will be tested at temperatures from room temperature to 1200°F. To carry out these thermal tests, the source will be heated in a closed system in which a carrier gas is passed over the source during the tests. The exit gas stream will be provided with a filter and scrubber which will permit collection and measurement of any particulate material released. Visual inspection of surfaces will be utilized in evaluating the integrity of the source after exposure to high temperature.

3. Pull Test

Radium needles will be subjected to a tension test to determine the force necessary to disengage the end plug. To carry out this test, the source body will be firmly clamped and a wire passed through the needle eyelet. The force required to pull the end plug loose will be measured.

4. Impact Test

Sources and plaques will be subjected to an impact test using a metal ball drop test similar to that described in ASTM 284-5IT. Metal balls will be dropped from various heights onto needles (both side and end) and onto the surface of the radium plaques. Following a predetermined number of drops, the sources will be tested for leakage.

5. Metallographic Examination

Sources incorporating various closure methods (solder, braze, etc.) and, in particular, those which are old will be subjected to a metallographic examination in order to determine (a) the condition of the source closure, and (b) any evidence of attack on the cladding material by the source compound.

The collecting and testing of sources for the second phase of the contract will take approximately one year.

V. Conclusion

A total of 64 radium sources were sent to Vallecitos Nuclear Center for testing. Of these sources, 39 were checked for leakage and surface contamination, 10 were used in decontamination studies, and 17 were used in destructive bending tests. At the conclusion of the tests, all radium was disposed of as radioactive waste.

Of the sources tested for leakage and surface contamination, 36% were found leaking and 41% contaminated. A leaking source did not necessarily show contamination nor a contaminated source leakage. The use of water to remove and/or loosen contamination on source surfaces seemed to be as effective as ethanol or acid, although the latter were effective in removing some surface deposits. Mechanical testing indicated that (1) source encapsulation (2) source cladding, and (3) degree of flexing, may determine to a large extent the ability of the source to resist rupture.

Further physical tests will be performed to measure radium source integrity. These will include room temperature leak testing, elevated temperature leak testing, pull tests, impact tests and metallographic examination. It is anticipated that this second phase of the contract will take approximately one year to complete.

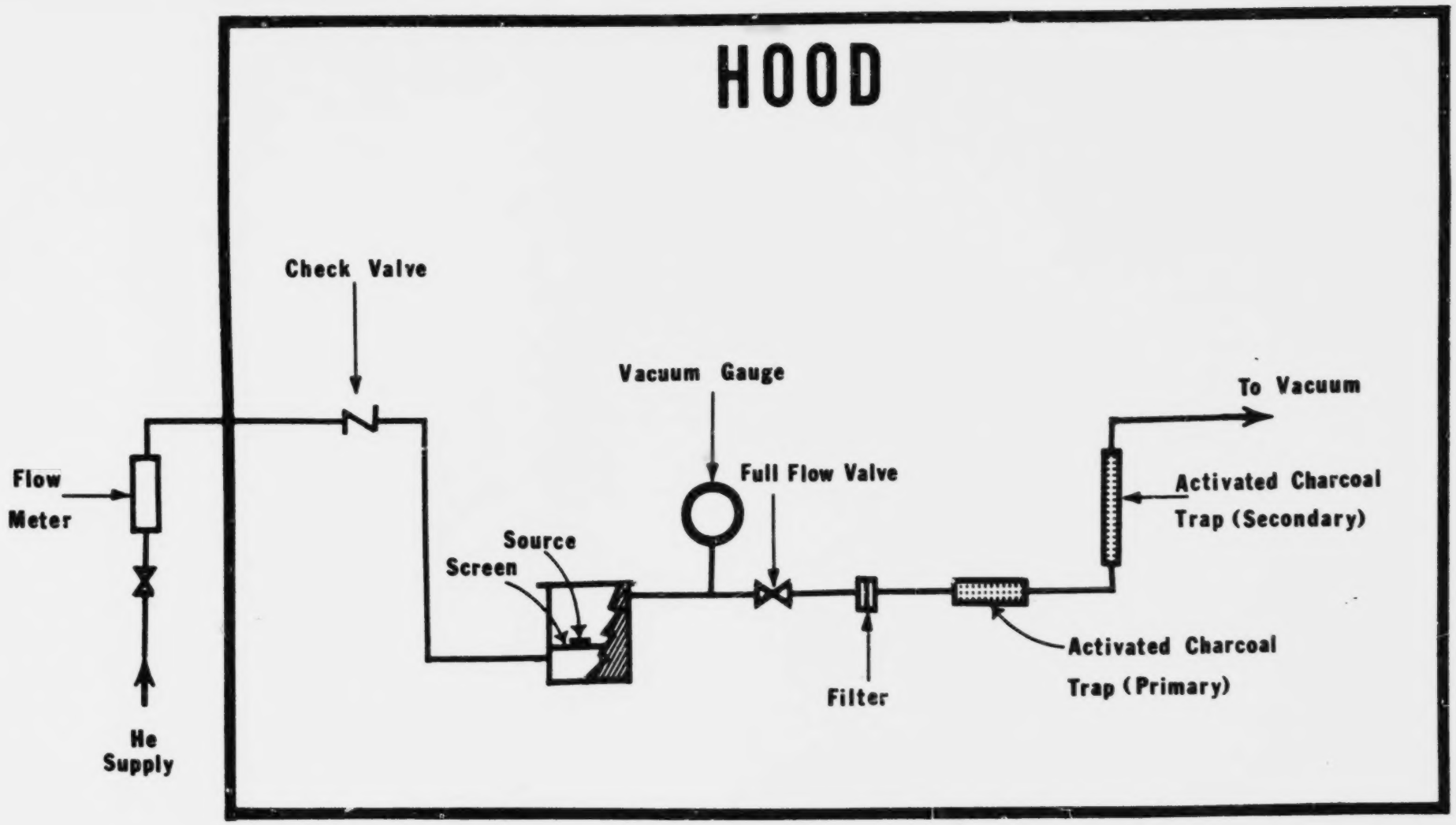


**Figure 1. Schematic of Leak Checking System**